APPENDIX A - PHASE I JUSTIFICATION

EMP Plan of Study

Shell Outer Continental Shelf Lease
Chukchi Sea, Alaska

May 2013

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FIGURES

ATTACHMENTS

1. PHASE I BASELINE SITE JUSTIFICATION

The environmental monitoring program (EMP) requires environmental monitoring at each drilling site during four different phases (Phases I through IV; Table 2 in EMP). The Phase I component of the National Pollutant Discharge Elimination System (NPDES) permit requires a "baseline site characterization," for which data collected under other agency requirements or in a voluntary fashion, within the most recent 5-year period at or in the vicinity of the drill site location, may be submitted for consideration of meeting this requirement. As such, the following section presents existing data that demonstrate the existence of sufficient baseline site-characterization data for the components listed in section II.A.f. of the NPDES permit:

1. Physical sea bottom;
2. Physical characteristics;
3. Receiving-water chemistry; and characteristics, and
4. Benthic community structure.

Additionally, baseline sediment characteristics and benthic bioaccumulation data are presented as per section II.A.j. of the NPDES permit. Empirical data from the past five years exist for the Chukchi Sea from two large, comprehensive baseline studies that have been conducted annually for three and five years, respectively. The Chukchi Sea Offshore Monitoring in Drilling Area: Chemistry and Benthos (COMIDA CAB), a government (Bureau of Ocean Energy Management [BOEM])-funded study, began in 2009 and has collected chemical and benthic-ecology data for three non-consecutive years: 2009, 2010 and 2012. The COMIDA CAB sampling stations in the northeastern Chukchi Sea are shown in Figure 1.

The Chukchi Sea Environmental Studies Program (CSESP), a joint industry-funded study began in 2008 and has collected a diverse and multi-disciplinary dataset for the past five years. CSESP studies included environmental chemistry and benthic ecology, as well as physical oceanography, marine mammals and seabirds, and other disciplines. CSESP data were collected over three 30x30 nautical mile areas (Klondike, Burger and Statoil). Only the Burger study area data (with some contemporaneous stations in the immediate vicinity of the Burger study area) are included here (Figure 1).

In addition, a discharge monitoring program (DMP) was conducted by Shell, in 2012, in which Phase I-equivalent data were collected at 18 stations around the Burger A drill site. The DMP stations represent spatially intensive sampling points and are shown in Figure 1 (insets). The goal of this section is to present and demonstrate that sufficient baseline data exist throughout the northeast Chukchi Sea that can serve as a replacement for Phase I sampling at Burger study area. The work described in the Phase I portion of this document consisted of compiling and analyzing data from the previous five years that represented different geographical parts of the Chukchi Sea. The data analysis was conducted to determine the variability within and among the data sets from the same region and to establish whether historical data from a larger geographical area may be predictive of current baseline data at site-specific locations.

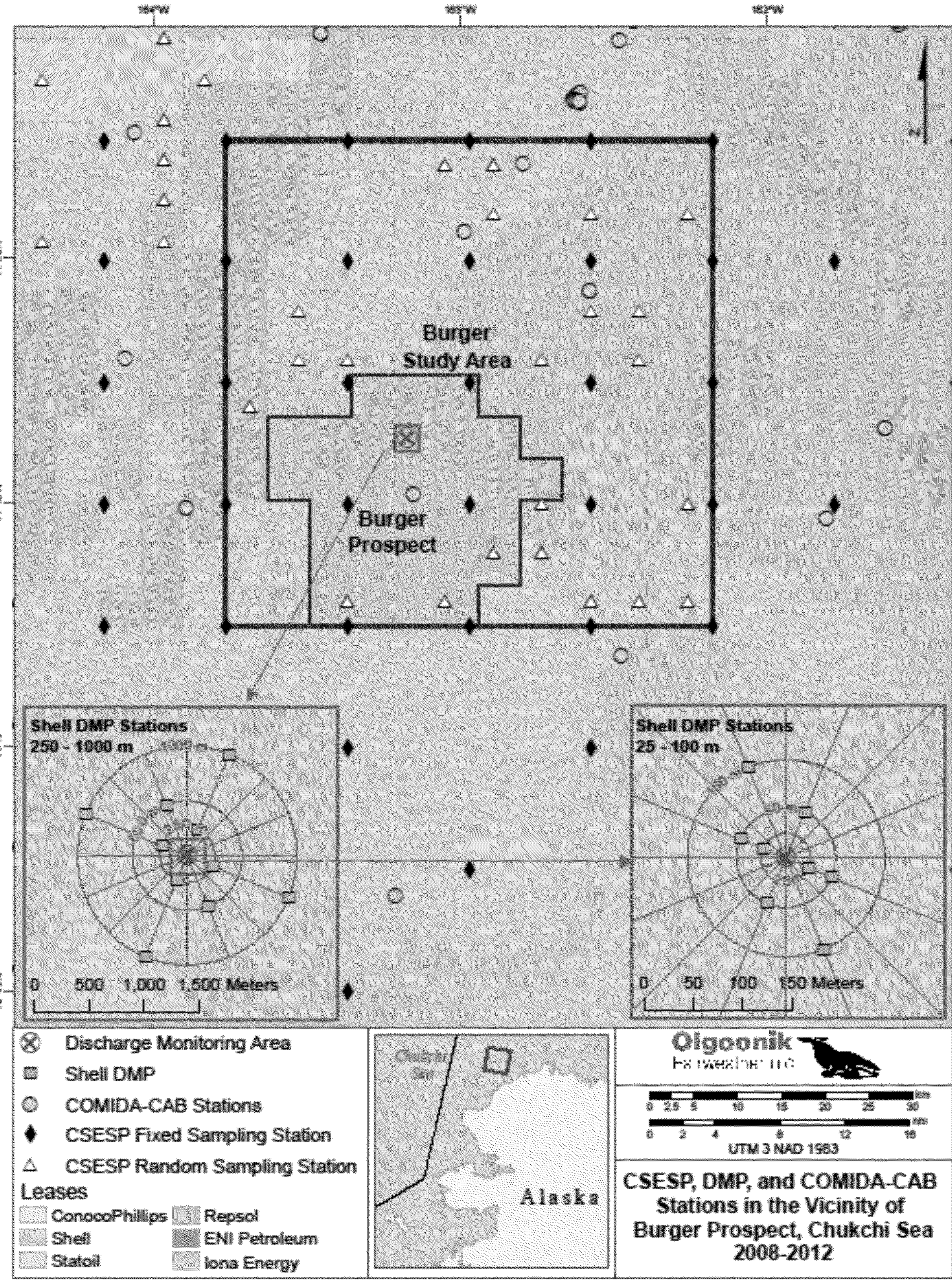


Figure 1: CSESP, DMP AND COMIDA CAB stations in the vicinity of Burger prospect, Chukchi Sea, 2008-2012.

These comprehensive programs (i.e., COMIDA CAB and CSESP) provide a unique collaboration of government -funded and industry -funded data sets that, in conjunction, support empirical evidence of a comprehensive baseline summary characterization of both the prospect-specific (e.g., Burger) environment and the greater outer continental shelf (OCS) Chukchi Sea environment. Data for the following disciplines, relative to the context of the NPDES permit are presented in this section:

1. Initial physical sea-bottom survey;
2. Baseline physical characteristics (physical oceanography);
3. Receiving-water chemistry and characteristics; and
4. Baseline benthic-community structure.

In addition, because Discharge 001 (water -based drilling fluids and drill cuttings) will be discharged, additional baseline data are required as per section II.A.13.j.2 and 3, inc luding 1) Sediment characteristics; and 2) Benthic community bioaccumulation monitoring. These baseline data will also be presented.

In summary, recent data demonstrate that the baseline at Burger study area has been characterized for the 1) initial site physical sea bottom survey; 2) physical characteristics; 3) receiving water chemistry and characteristics (with the exception of hydrocarbons, which will be included in the EMP), and; 4) benthic community structure. These existing data are sufficient to serve as Phase I baseline site characterization data, as per the NPDES permit, and meet the Phase I data collection requirements.

1.1. Initial Site Physical Sea-bottom Survey

Digital videos, sediment -profile imaging (SPI) profile photographs, plan -view photographs, and benthic-ecology assessment data that were collected between 2008 and 2012 under the CSESP and Shell DMP indicate that there do not appear to be any "sensitive bio logical areas or habitats" that can be designated as critical or unique in the Burger prospect. Based on data collected in 2012 at the Burger A drill site, there is no indication that this well site is located "in or near a sensitive biological area or hab itat." Similarly, a comparison of the data from the Burger A drill site and the broader Burger study area indicates that it is reasonable to extrapolate from the broader site data to the smaller spatial locations of the individual drill sites. Plan-view and cross-sectional digital images collected using SPI in 2012 are presented in Attachment A : Burger A Pre-Drill SPI Survey Report.

Video and plan -view digital (i.e., camera sled [Figure 2] and SPI [Figure 3]) pictures from the Burger study area indicate a muddy environment with the surface dominated by the brittle star *Ophiura sarsi*. Turbid water (caused by storms) resulted in non -ideal conditions for plan -view photography in 2012. Nevertheless, available photographs document conditions in 2012 similar to those from 2011, with muddy sediments and brittle stars dominating surface sedi ments. Qualitative examination of the photographs indicate consistent conditions in surface sediments within the Burger A drill site. SPI profile photographs depict an upper layer of light tan -colored sediment indicating biologically -active infauna (invert ebrate animals residing within the sediments) and darker sediments below with tube -dwelling infauna. Thus the SPI photographs indicate a sedimentary environment and level of biological activity expected in fine-grained sediments.

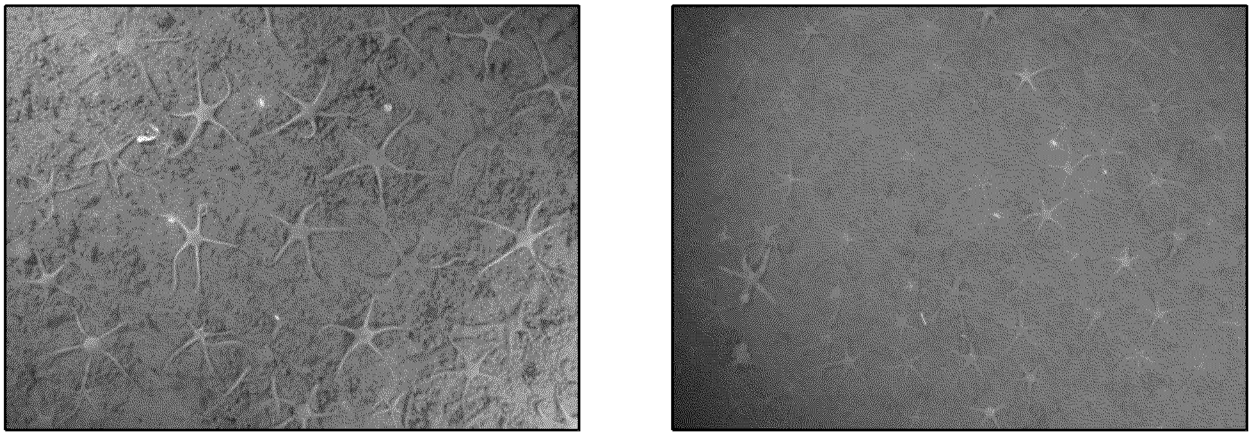


Figure 2: Digital still photographs taken from the Burger study area in 2011. Photographs were extracted from videos taken during the 2011 CSESP. The red dots are separated by 10 cm, and the total frame size is approximately 50cm x 28cm with an area of about 0.14 m^2.

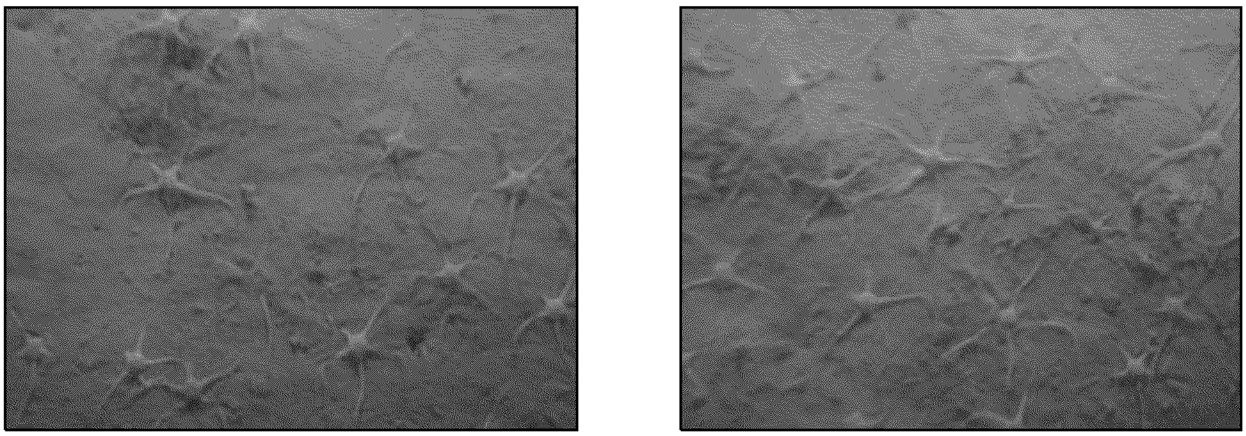


Figure 3: Digital still photographs taken from the Burger A drill site in 2012. Photographs are examples of those collected in the Shell DMP, taken with the sediment profile imagine equipment, and provided by John Hardin, Battelle. The red dots are separated by 10 cm and have been enhanced for visibility.

1.2. Physical Characteristics

1.2.1. Winds, Currents, Temperature and Salinity

Physical data collected for the past five years in the OCS Chukchi Sea under the CSESP and COMIDA programs include surface wind speed and direction, current speed and direction throughout the water column, water temperature, salinity, depth and turbidity. Data collected from the northeastern Chukchi Sea over the past five years include shipboard measurements of vertical profiles of temperature and salinity, velocity measurements from year-round oceanographic moorings, satellite-tracked drifters, and shore-based surface current-mapping radars that are operating during the open -water season from August through late October. These data are supplemented by historical data sets (shipboard and moorings only) from the northeastern Chukchi Sea shelf. In aggregate, the recent and historical data sets have provided an understanding of seasonal transitions in water properties (temperature and salinity) and the circulation of the Burger study area and, on larger scales, the northeastern Chukchi Sea shelf. This information has been reported by Coachman et al. (1975), Martin and Drucker (1997), Weingartner et al. (1998, 2005, In press), Winsor and Chapman (2004), Woodgate et al. (2005a, 2005b), Pickart et al. (2005), Spall (2007), Mudge et al. (2010), and Timmermans and Winsor (2013). In addition, several publicly-accessible websites provide additional information and data, some of which (e.g., meteorological reports, data from shore-based current-mapping radars, satellite drifters) provide data in real-time during the open-water season. These websites include:

- http://www.ims.uaf.edu/hfradar/ ;
- http://dm.sfos.uaf.edu/chukchi-beaufort/data/drifters/ ; and
- http://www.ims.uaf.edu/chukchi/ .

The temperature and salinity properties of the Chukchi shelf undergo seasonal transitions that are a consequence of freezing and thawing (largely governed by the annual cycle in solar radiation) and transport of water masses northward from the Bering Sea. In the summer and fall months, Bering Sea summer waters are an important source of heat that accelerates ice retreat (in summer) and delays fall ice formation. By the end of the winter, water column temperatures are vertically and nearly horizontally uniform at the freezing point of seawater (approximately −1.7 degrees Centigrade [°C]). Salinity also is vertically uniform at this time and ranges from 32 to 33 parts per thousand (ppt). By early summer, these dense waters, all of which were formed during the previous winter, are found across the entire northeastern Chukchi shelf. As ice-melt begins in spring, the water column stratifies because the surface layer is diluted by fresh ice meltwater that is less dense than the salty bottom waters. Depending on mixing and the rate of ice-melt, the upper 5-15 meters (m) of the water column has salinities between 27 and 30 ppt. Spring and mid-summer surface temperatures can range from approximately −1°C to approximately +4 °C, with the warming largely being a consequence of solar warming of the meltwater. Through July, much of the northeastern Chukchi shelf, and the Burger study area in particular, is characterized by a strongly salt-stratified water column. By August, the stratification of the northeastern Chukchi shelf weakens with the arrival of less stratified, moderately salty, and warm waters from the Bering Sea. These waters infiltrate the Burger study area from the west and south, leading to a reduction in stratification as surface meltwaters and dense winter bottom waters gradually are displaced from the region. Within the Burger study area, the replacement of these water masses typically is completed by mid- to late September. The erosion in stratification also is accelerated in fall as wind speeds increase (generally) and solar heating diminishes, and the water column typically is well-mixed again by mid-October. An example of the August-September transitions in water column temperature and salinity over the northeastern Chukchi Sea (including Burger prospect) is shown in Figure 4.

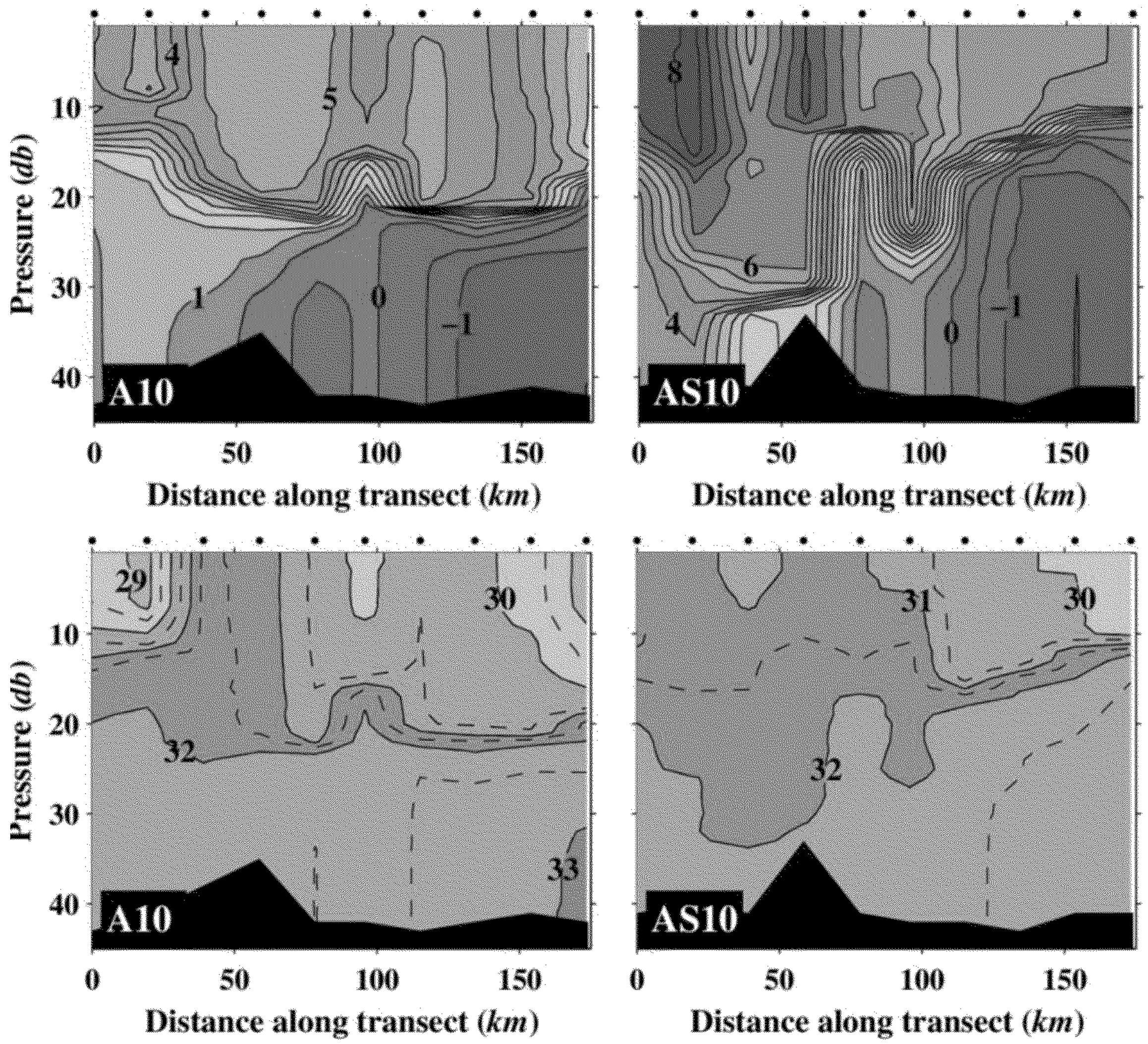


Figure 4: Temperature (top) and salinity (bottom) cross -sections across the northeastern Chukchi Sea in early August (A10; left) and late August to mid-September (AS10; right), 2010.

Currents over the northeast Chukchi shelf and in the Burger study area south of Hanna Shoal generally flow eastward across the shelf and toward the coast of northwestern Alaska. This flow, which arises from differences in ocean pre ssure between the Pacific and Arctic oceans, is responsible for the regional transport of summer Bering Sea waters into the area. Mean current speeds in the Burger region during the ice -free season range between 5 and 10 centimeters (cm) per second (s^{-1})(0.1-0.2 knots [kt]) and flow toward the east. The variability of the current strength is related primarily to variations in the strength and direction of the winds. On average, winds blow from the eastern (northeast, east or southeast) octants about 45% of the time in July, with this percentage increasing to 60% in October. The frequency distributions of winds blowing from the other octants are roughly comparable in these months, with each octant accounting for 5 to 10% of the total. The existing data sugges t that the flow begins to reverse (at least at the surface) when winds from the east or northeast exceed ~6 m s^{-1} (12 kt). Winds generally are weak during July and August, when <30% of the winds speeds from the eastward octants exceed

6 m s^{-1}. Hence, currents in the Burger prospect tend to be comparable to the mean about 70% of the time during these months. In September and October, wind speeds exceeding 6 m s^{-1} occur about 35% of the time. This increase in wind strength is associated with an increase in current variability. Currents vary principally between being eastward and westward in the Burger prospect. As a consequence of fall storms, the mean flow conditions occur ~40-50% of the time in September and October. Maximal wind-driven current speeds are 40-50 cm s^{-1} (0.8-1.0 kt) and may persist for periods of two to several days. Although these larger currents may occur anytime during the open-water season, they are more common in the fall when stronger winds associated with fall storms move through the region. The velocity field also is highly correlated spatially over the northeastern Chukchi shelf. In general, there is little velocity difference (shear) between surface and subsurface layers of the water column. However, the magnitude of the velocity shear depends upon the strength of the stratification, in that strongly stratified waters tend to have greater shear because stratification traps the momentum imparted by the winds to the surface layers.

In conjunction with the existing data sets for the Chukchi Sea, shore-based radars operate throughout the open-water season. The current data generated from the shore-based radars includes data covering the Burger prospect. These data are publically available in real-time on the internet at http://www.ims.uaf.edu/hfradar/animation/.

1.2.2. Water Depth and Turbidity

Bathymetric data and individual sampling station data from both the CSESP and COMIDA CAB studies demonstrate that water depth is well characterized in the Chukchi Sea and within the Burger prospect. Water depths in the Burger prospect are shallow and consistently range from 40 to 50 m.

Data from COMIDA CAB indicate that the concentrations of total suspended solids (TSS) in the upper 30 m of the water column for the combined 2009 and 2010 data set for the northeastern Chukchi Sea (n = 84) averaged 0.27 ± 0.18 (standard deviation [SD]) milligrams per liter (mg/L) with a range of 0.07 to 0.74 mg/L (Table 1). In the Burger study area, TSS values averaged 0.31 ± 0.23 mg/L and ranged from 0.13 to 0.38 mg/L, for water depths in the upper 30 m. In contrast, at water depths greater than 30 m, values for TSS in the northeastern Chukchi Sea during both 2009 and 2010 averaged 1.8 ± 0.8 (SD) mg/L, almost seven times higher than found in the upper water column (Table 1). In the Burger study area, TSS averaged 1.1 ± 0.57 mg/L and ranged from 0.73 to 1.54 mg/L for water depths greater than 30 m. Most vertical profiles for TSS show a clear trend of lower values in surface water and distinctly higher values below the pycnocline, in the lower 20 m of the water column. As previously mentioned, bottom currents in the eastern Chukchi Sea have an annual average flow of ~5 to 10 cm s^{-1} with maximal values as high as 45 cm s^{-1} (Weingartner et al. 2005), sufficient to re-suspend bottom sediments. A strong pycnocline and shear across that density boundary seem to confine re-suspended sediments to the bottom 20 m of the water column. Lower values for TSS in surface water also are limited by a minor influx of river runoff to the northeast Chukchi Sea.

Table 1: Summary data for total suspended solids collected from the Chukchi Sea during the 2009 and 2010 COMIDA surveys.

	2009	2010	2009	2010	2009	2010
	<30 m	<30 m	>30 m	>30 m	>30/<30 m	>30/<30 m
Total Suspended Solids (mg/L)						
Mean	0.29	0.26	2.41	1.55	8.4	5.9
SD	0.19	0.17	0.96	0.55	-	-
N	34	50	14	25	-	-
Max	0.69	0.74	4.29	2.47	-	-
Min	0.08	0.07	1.23	0.73	-	-

The composition of the suspended particles also was distinctly different in surface versus bottom water. For example, concentrations of particulate Al (as a % of TSS) averaged 1.0 ± 0.9% in the upper water column vs. 3.8 ± 1.8% for samples collected at gre ater than 30 m water depth during 2009 and 2010. This trend was consistent with greater amounts of re -suspended aluminosilicates (silt and clay minerals) than would be expected in the lower water column relative to the upper water column. In contrast with the trend for particulate Al, concentrations of particulate organic carbon (POC) as a % of TSS for 2009 plus 2010 averaged 19 ± 9% at water depths <30 m and 9 ± 7% at water depths >30 m (Table 1). Thus, more organic -rich and clay -poor particles were collected from the upper part of the water column and vice versa for the lower part of the water column (Table 1).

1.3. Receiving Water Chemistry and Characteristics

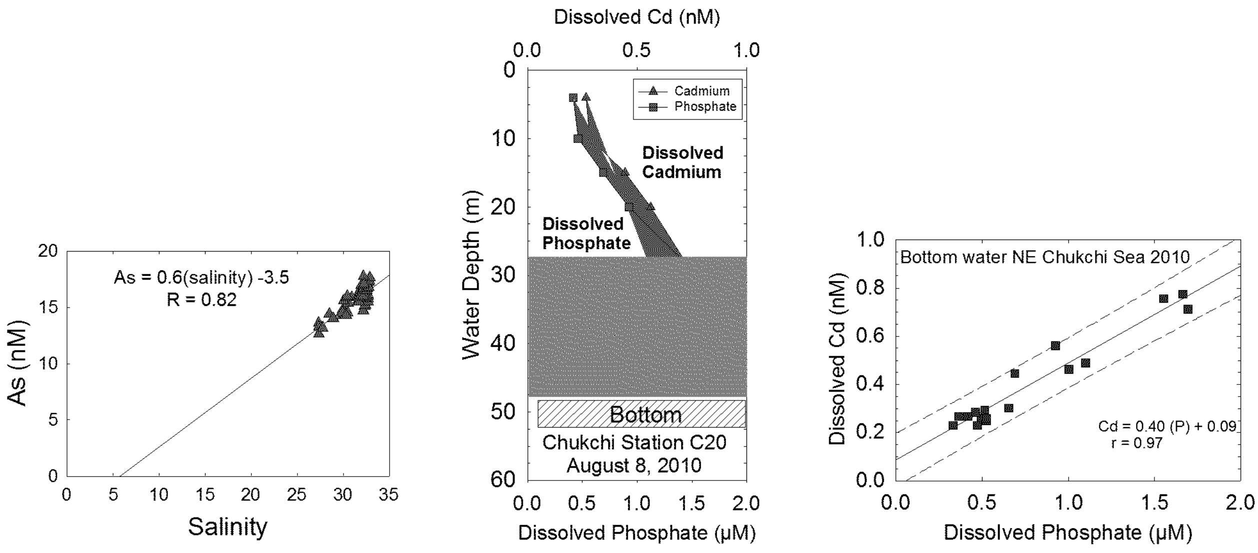
1.3.1. Metals

Concentrations of dissolved metals were determined for six samples from the Burger study area and 88 samples from the northeastern Chukchi Sea during 2010 (Table 2). Concentrations of some metals, including aresenic (As), barium (Ba), antimony (Sb), selenium (Se) and thallium (Tl), seem to track salinity and have small relative standard deviation (RSD) values of 3% to ~20% in both the Burger study area and throughout the northeastern Chukchi Sea in general (Table 2 and As vs. salinity shown in Figure 5A). The nutrient -type metals, including cadmium (Cd), copper (Cu), nickel (Ni) and zinc (Zn), are p resent in low concentrations in nutrient - depleted surface waters and are enriched due to remineralization in bottom waters (Figure 5B); therefore, concentrations of these metals correlate strongly with concentrations of nutrients (Figure 5C). Average conce ntrations of potential contaminants such as lead (Pb) and mercury (Hg) are very low, at <5 and 0.5 parts per trillion (ng/L), respectively. These data seem to characterize the concentrations of dissolved metals in the northeastern Chukchi Sea well and seem suitable and reliable for locations throughout the northeastern Chukchi Sea as a whole, including the Burger A, J, F, R, S and V drill sites.

Table 2: Concentrations of dissolved metals (mean ± SD) for water samples from 2010 for the Burger study area and northeastern Chukchi Sea as a whole.

Parameter	As	Ba	Cd	Cr	Cu	Total Hg	Ni	Pb	Sb	Se	Tl	Zn	TSS
Burger study area (2010; *n* = 6)													
Mean	1.16	7.7	0.046	0.13	0.24	0.0005	0.32	0.004	0.13	0.034	0.009	0.33	0.59
SD	0.04	1.2	0.024	0.07	0.04	0.0003	0.08	0.002	0.01	0.002	0.001	0.06	0.52
RSD[1]	3	16	52	54	17	60	25	50	8	6	11	18	-
Northeastern Chukchi Sea (2010; *n* = 88)													
Mean	1.15	8.2	0.046	0.10	0.27	0.0005	0.32	0.006	0.12	0.034	0.010	0.45	0.80
SD	0.12	2.0	0.021	0.02	0.10	0.0003	0.08	0.002	0.01	0.006	0.002	0.26	0.88
RSD[1]	10	24	46	20	37	60	25	33	8	18	20	58	-

metals measurements = μg/L
TSS = mg/L
[1]RSD = (SD/mean) x 100%



(A) (B) (C)

Figure 5: (A) Dissolved As vs. salinity, (B) vertical profiles for dissolved phosphate and Cd, a nutrient-type metal, and (C) concentrations of dissolved Cd vs. phosphate for bottom water in the northeastern Chukchi Sea (from Dunton et al. 2012).

1.3.1.1. Justification for Revised List of Metal Contaminants of Concern for Water Analysis

In accordance with the NPDES permit that "the permittee may propose an alternative list [of metals] based on site -specific data" (p. 21, OCS Chukchi NPDES permit), six selected metals from the suite of 19 for dissolved water analysis (NPDES permit, Table A, Metal contaminants of concern) will be removed from consideration as part of the receiving water chemistry (dissolved water analysis) assessment. The justification for removal of these six metals, aluminum (Al), iron (Fe), titanium (Ti), silver (Ag), antimony (Sb), and beryllium (Be), falls into three categories:

1. Metals with extremely low water solubilities and/or are naturally at extremely low concentrations in water;
2. Metals that are present at or below background sediment concentrations in drilling-related products, such as water-based muds (WBMs) and cuttings (e. g., Al, Ti, Fe, Ag, Be); and
3. Metals with analytical challenges associated with measuring trace concentrations (related to extremely low water solubilities of particular metals) and, hence, the significant likelihood of introducing background contamination.

The metals Al, Fe and Ti are major elements in sediments; however all three have very low solubility in water and tend to adsorb on particles. As such, particulate/suspended water concentrations are more informative for understanding concentrations of these metals in the discharge plume(s). For example, iron concentrations are sometimes so low in the ocean that they have long been known to limit primary productivity (Martin and Fitzwater 1988). Fe and Al can be useful particulate tracers and will be analyzed in particulate/suspended water samples.

The metals Ag, Sb and Be are present at extremely low (i.e., part per trillion) concentrations in water. Consequently, analysis of these metals in WBMs and cuttings will serve as confirmation that these metals typically are not recorded beyond background concentrations as a result of exploratory drilling operations.

Because the concentrations of these three metals are so low in water, the chance for accurate analytical results is low. These elements also are not toxic in seawater at concentrations well above natural values.

In summary, the following list of metals (Table 3) will be analyzed in dissolved water samples collected during Phase II monitoring. Note that sediments samples collected during Phases III and IV will be analyzed for the full suite of metals listed in the permit.

Table 3 : List of metals (13) for analysis of dissolved water samples collected during drilling monitoring.[1]

Arsenic (As)	Methyl Mercury (MeHg)
Barium (Ba)	Nickel (Ni)
Cadmium (Cd)	Selenium (Se)
Chromium (Cr)	Thallium (T1)
Copper (Cu)	Tin (Sn)
Mercury (Hg)	Zinc (Zn)
Lead (Pb)	

[1]In addition, the following metals will be analyzed in particulate form: aluminum (Al), iron (Fe), barium (Ba), chromium (Cr), antimony (Sb) and zinc (Zn), to augment plume monitoring assessment of metals.

1.3.1.2. pH, Turbidity and Total Suspended Solids

Data on pH, turbidity and total suspended solids are well characterized in receiving waters in the Burger study area. pH data were collected in the Chukchi Se a during the CSESP program in 2010 and 2011 (Mathis 2011). pH values were calculated from total alkalinity measurements and, for the months of August and September 2010, averaged 8.16 ± 0.08 (SD) at a water depth of 1 m, 8.18 ± 0.09 (SD) at 5 m, and 8.15 ± 0.07 (SD) at 10 m (Mathis, 2011). Turbidity and total suspended solids baseline data in the Burger study area and northeastern Chukchi Sea w ere addressed in Section 1.2.2.

1.3.2. Total Aqueous Hydrocarbons and Total Aromatic Hydrocarbons

Concentrations of hydroc arbons in water typically are very low and do not provide a representative evaluation over a temporal scale. In addition, sediment and tissue concentrations (as well as source samples, such as muds and cuttings) are more applicable for monitoring and assessing impacts of hydrocarbons in the context of ex ploratory drilling operations. Baseline hydrocarbon concentrations from recently collected seafloor sediments and biota tissue are provided in this appendix.

Receiving water samples will therefore be collect ed during the Phase II (during drilling) component (rather than during a Phase I component) at reference stations in far -field areas located approximately 1,000 m from the drilling discharge location. These water samples will serve as contemporaneous refer ence samples for evaluation of receiving -water chemistry and characteristics and will be compared to the water samples collected in near -field areas during plume monitoring for hydrocarbon analyses. The comparison between the near -simultaneous collection o f water samples, both within and outside of the discharge plume(s), will serve as a more robust means of determining differences between elevated hydrocarbon concentrations in the plume and the typical "background" hydrocarbon concentrations in Chukchi Se a receiving waters.

1.4. Benthic Community Structure

The CSESP study provides extensive information concerning the benthic ecology (infauna, invertebrate animals residing within the sediments and epifauna, and invertebrate animals living on sediment) of the Burg er study area. The CSESP study sampled 26 stations for infauna in the Burger study area annually from 2008 to 2012 , and nine stations were sampled in both 2011 and 2012. Eighteen Phase I -equivalent (i.e., baseline) samples were also collected in 2012 at th e Burger A drill site location. An additional two stations were sampled for infauna in the Burger study area during the COMIDA program (Dunton et al. 2012). Trawling for epifauna occurred at 13 stations in the Burger study area from 2009 to 2010 (CSESP) wi th two stations sampled for epifauna in COMIDA. These data provide a strong baseline for understanding the biological and environmental characteristics of the Burger prospect and different drilling locations.

The ecology of benthic communities in the north eastern Chukchi Sea has been a focus of research since the 1970s. Initial research in the area by U.S. scientists was conducted by Stoker

(1981), who demonstrated broad -scale trends across the Bering and Chukchi seas. Feder et al. (1994) sampled benthic communities in the northeastern Chukchi Sea in 1986, providing details on the environmental characteristics associated with benthic community structure. Later, investigations sampled communities from the western Chukchi and s elected sites in the Chukchi, and investigated ecological processes at the shelf margin (Grebmeier et al. 2006, 2009; Bluhm et al. 2009). However, it was only in 2008 that sampling of benthic communities for understanding community ecology was again conduc ted in the region , and it was not until 2010 and 2011 that broad-scale research was conducted (Dunton et al. 2012; Blanchard et al. in press a , 2013). Overall, the importance of advected water on benthic communities is now understood, with the benthic asse mblages strongly influenced in their composition and production reflecting the nutrient characteristics of water masses (Feder et al. 1994; Grebmeier et al. 2006). Associations between environmental characteristics and benthic communities reflect the covar iance of sediment characteristics and faunal communities with water circulation. Increased benthic productivity is apparent in areas with altered water circulation (e.g., points, shoals and canyons) (Feder et al. 1994, 2007; Grebmeier et al. 2006), indicat ing the importance of large -scale processes as controls on benthic communities (Blanchard et al. in press a , Blanchard and Feder in press; Weingartner et al. In submission).

The infaunal community in Burger study area is dominated numerically by polychaete s and bivalves (Table 4). The maldanid polychaete worm *Maldane sarsi* is a numerically dominant organism throughout the offshore environment of the northeastern Chukchi Sea by density and biomass with extremely high densities at some sites in Burger study a rea (Feder et al. 1994; Blanchard et al. 2011, Blanchard et al. in press a, Blanchard and Feder in press). The polychaete *Scoletoma* spp. and crustaceans, including ostracods and amphipods such as *Photis* spp., also occur in moderate densities. The bivalve *Ennucula tenuis* is a dominant organism by density and biomass, with larger bivalves such as *Astarte borealis* and *Macoma calcarea* and the peanut worm *Golfingia margaritacea* occurring in substantial biomass as well.

Table 4: Numerically dominant organisms (to p 5) by density (individuals m $^{-2}$) and biomass (grams m^{-2}) for the Burger study area. Values are averaged from the 2008-2011 studies.

Infauna			
Taxon	**Density**	**Taxon**	**Biomass**
Maldane sarsi	1,093	*Astarte borealis*	45.7
Ostracoda	282	*Macoma calcarea*	43.7
Ennucula tenuis	203	*Golfingia Margaritacea*	40.4
Scoletoma spp.	140	*Maldane sarsi*	40.1
Photis sp.	129	*Ennucula tenuis*	28.9
Epifauna			
Common name	**Density**	**Common name**	**Biomass**
Brittle starts	86.1	Brittle starts	55.2
Snails	3.5	Snails	5.6
Sea cucumbers	3.1	Sea cucumbers	4.5
Shrimps	1.9	Crabs	3.3
Amphipods	0.5	Basket stars	2.1

The epifaunal community is dominated numerically by the brittle star *Ophiura sarsi* in the Burger study area and throughout many parts of the northeastern Chukchi Sea (Table 4; Bluhm et al. 2009; Blanchard et al. 2011, Blanchard et al. in press a). Sea cucumbers and snails are also dominant.

One method of evaluating community-level variation is rankings of infauna by density and biomass. Comparisons of dominant organisms via station rankings can provide insights into what constitutes acceptable ranges of community variation in density and biomass within the Burger study area. Here, community-level variations among stations are demonstrated by ranking infauna from the station with the lowest density versus the highest density from 2008 to 2011 (Table 5). The rankings provide insights into communities under different environmental regimes in Burger study area stations, and a background for comparison of Burger drill sites. The numerically-dominant species in the stations with minimal (BF025 in 2010) and maximal (BF013 in 2011) densities reflect the overall dominants in the Burger study area and within the entire CSESP study area (Blanchard et al. in press b). The dominant species in both stations are organisms that are found throughout the study area and that are common in soft sediments (i.e., none of the species or patterns of composition deviate from the expected patterns for the area).

Table 5: Numerically dominant organisms (top 5) by density (individuals/m ^{2}) and biomass (g/m ^{2}) for the station with the lowest and highest density values for the Burger study area from the 2008 - 2011 CSESP.

Year	Station	Taxon	Abundance	Taxon	Biomass
2010	BF025	*Macoma calcarea*	193	*Macoma calcarea*	215.44
		Cirratulidae	77	*Macoma moesta*	13.31
		Dipolydora sp.	57	*Ennucula tenuis*	12.80
		Ennucula tenuis	50	*Periploma aleuticum*	12.74
		Pholoe minuta	43	*Cyclocardia crebricostata*	6.67
		Nephtys punctate	13	*Priapulus caudatus*	0.93
2011	BF013	*Maldane sarsi*	9,443	*Neptunea heros*	107.24
		Ostracoda	1,083	*Golfingia margaritacea*	82.73
		Ennucula tenuis	550	*Ennucula tenuis*	55.40
		Photis sp.	437	*Cyclocardia crebricostata*	10.36
		Barantolla americana	230	*Musculus discors*	5.24

Overall, benthic communities in the Burger study area, based on 2008-2012 data, are similar in composition to those found in prior years and within the Chukchi Sea as a whole (Feder et al. 1994; Grebmeier et al. 2006). The dominance of densities by *Ennucula tenuis* and *Maldane sarsi* and of biomass by large bivalves in 1986 and 2008-2012 demonstrates that, at least very broadly, communities have temporally persistent biological characteristics. Recent investigations of megafauna indicate the widespread distributions of the brittle star Ophiura sarsi and the snow crab Chioniocoetes opilio, both of which were present at the Burger A drill site, as well as in the Burger prospect (Bluhm et al. 2009; Blanchard et al. in press b).

The numerically dominant species and the benthic assemblages in general reflect the influence of species advected into the Chukchi Sea from the north Pacific through the Bering Sea (Feder et al. 1994; Grebmeier et al. 2006; Bluhm et al. 2009; Dunton et al. 2012; Blanchard et al. in press a, b, 2013). The northward-flowing water advects benthic larvae and organisms into the Arctic, resulting in a high similarity of communities from the Gulf of Alaska to the northeastern Chukchi Sea (Blanchard et al. in press a). Overall, the benthic community in the Burger study area observed through sampling in the 2008-2012 CSESP study is a common assemblage found in soft-bottom and muddy sediments throughout Alaska.

Recent news releases suggest that sensitive species, specifically soft corals, were newly discovered in the Burger study area and are a critical habitat at the drilling location (http://www.greenpeace.org/usa/en/media-center/news-releases/Abundant-corals-discovered-at-Shells-Chukchi-drill site/). The soft coral in question, the Sea Raspberry (*Gersemia fruticosa* and *G. rubiformis*), is well-known and widely dispersed throughout the north Pacific, the Bering Sea, Alaska's coastal waters, and the Chukchi Sea. Based on the extensive CSESP sampling from 2008 to 2011, there do not appear to be any habitats or species that can be designated as critical or unique in the Burger study area or specific Burger drill sites. Additional support for this conclusion can be found in the rejection of "petition to list 44 coral species under the Endangered Species Act (ESA)" published in February 2013 in the Federal Register (Federal Register, volume 78 number 31).

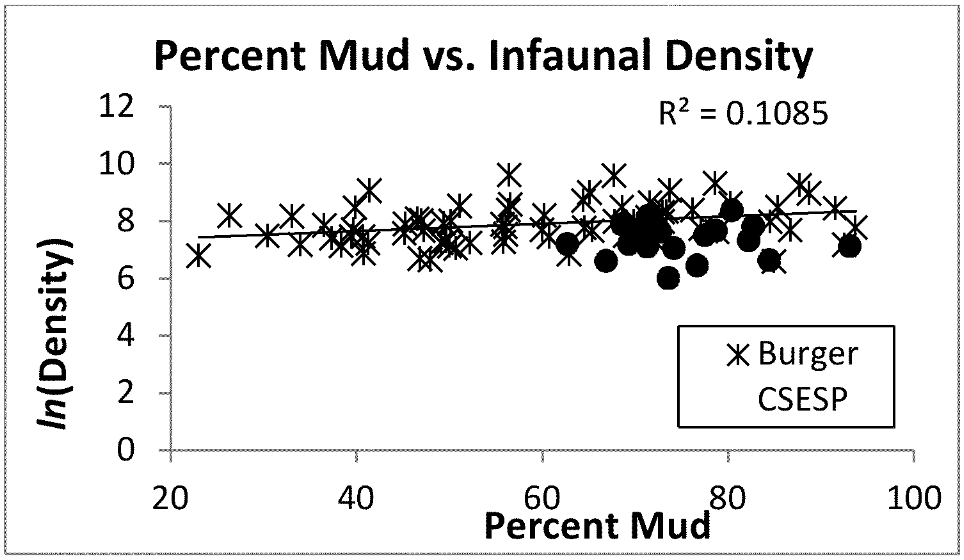
Benthic sampling for infauna occurred at 18 stations in the Burger A drill site during the Phase I-equivalent (i.e., baseline) Shell DMP in 2012. Comparison of the CSESP data for Burger study area with the location-specific data from 2012 provides insights into how representative the other Burger stations are of specific drill site locations. The following question is specifically addressed: "Are the data from the CSESP program adequate to serve as a baseline for post-drilling monitoring at prospects?" To answer this question, data were compared using faunal rankings and regression to determine whether data from the Burger A drill site fall within the trends observed in the data sets from the Burger study area as a whole. Therefore, data are averaged across all stations to determine average faunal densities for the Burger A drill site.

Data from three replicate samples collected at each station indicate that the greatest difference between the Burger A drill site overall and the Burger study area stations from the CSESP study is that the numbers of *Maldane sarsi* in the Burger A drill site are low (Table 6). Densities of *M. sarsi* in the CSESP ranged from an average of 3 to 9,500 individuals m^{-2} at some stations, whereas densities from the 2012 DMP at Burger A drill site ranged from 10 to 70 individuals m^{-2}. Overall densities appear to be toward the low end of the range. The remaining numerical dominants at Burger A drill site also were found throughout the Burger study area in the CSESP study. The location-specific community, however, fits well within the community-level variability observed within the Burger study area stations (Tables 4 and 5). The similarity of the stations is indicated by the consistent presence of key dominants throughout the drilling location including *Barantolla americana, Ennucula tenuis, Golfingia margaritacea, Macoma calcarea* and *Maldane sarsi,* all of which are found in Burger A drill site stations.

Table 6: Numerically dominant organisms (top 5) by density (individuals m $^{-2}$) and biomass (g m^{-2}) for the Burger A drill site. Values are averaged from 18 stations sampled at Burger A drill site in 2012. The density and biomass of *Maldane sarsi* also are presented, although they are not in the top 5 in either category.

Taxon	Density	Taxon	Biomass
Ostracoda	276	*Golfingia margaritacea*	87.6
Ennucula tenuis	202	*Macoma calcarea*	62.7
Barantolla americana	99	*Ennucula tenuis*	22.6
Ektondiastylis robusta	79	*Ophiura sarsi*	11.7
Terebellides stroemi	66	*Paradiopatra parva*	5.5
Maldane sarsi	31	*Maldane sarsi*	2.6

Community characteristics of the Burger A drill site were also evaluated with regression. Total infaunal density and biomass for the Burger study area stations from the 2008 -2011 CSESP (the 2012 samples are currently being processed) and the Burger A drill site from the 2012 DMP were regressed against percent mud (Figure 6). The biological data were *ln*-transformed to meet statistical assumptions, and the transformed data are presented here. The relationships between percent mud and the biological variables are weak, with R^2 accounting for 10% of the total variability in infaunal density and only 3% of t otal variability for biomass. (Low R^2 values are not uncommon when considering a single variable in benthic studies and can be improved dramatically with the addition of other covariates.) Specifically, these relationships demonstrate that the Phase I -equivalent (i.e., baseline) samples collected in Burger A drill site in 2012 fall within the continuum for the CSESP stations as a whole. Although more muddy than most stations, the DMP stations fall well within the boundaries of the regression, based on the o ther Burger study area stations. Thus, although the community structure does vary somewhat from that expected for the Burger study area due to low numbers of *M. sarsi* (Tables 4 and 5 vs. Table 6), the community falls within the general trends for the CSESP and Burger study area. Micro - scale deviations in environmental conditions and biological characteristics are to be expected. The regression and faunal data demonstrate that the community in the Burger A drill site fits within the mid -scale gradients in the Burger study area and the macro -scale gradients in the northeastern Chukchi Sea.



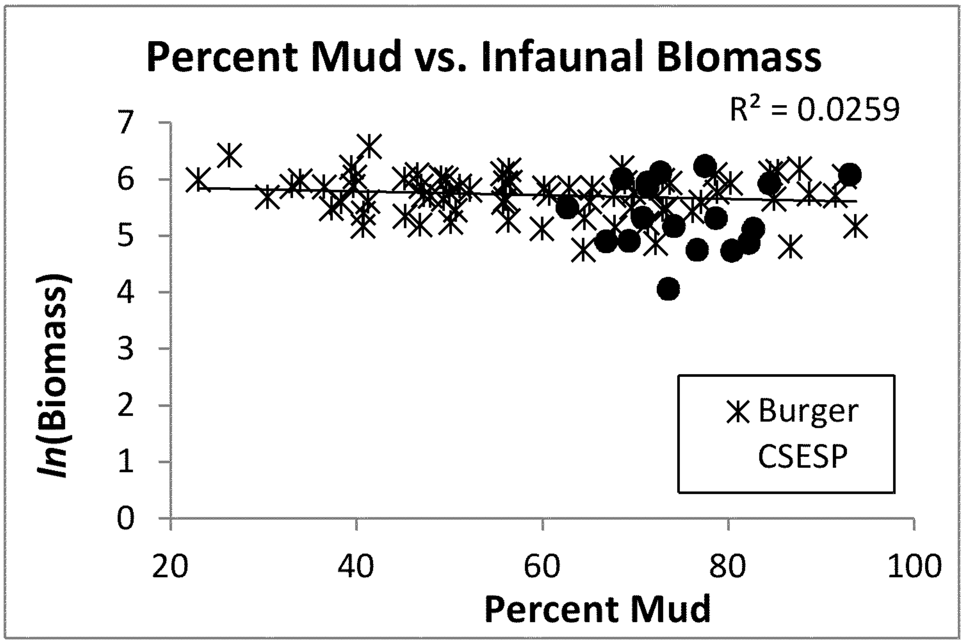


Figure 6: Percent mud regressed against *ln*-transformed infaunal density and biomass data from the 2011 CSESP study of the Burger study area and Burger A drill site samples from 2012 (DMP).

1.5. Sediment Characteristics

Section II.A.13.j.2 of the NPDES permit requires baseline data for sediment characteristics. Baseline concentrations of potential contaminants in sediments are needed to determine whether anthropogenic inputs of the contaminants are present in samples collected in Phase III or Phase IV field efforts following cessation of drilling a well at a particular site. Because trace metals and hydrocarbons occur naturally in the environment at different concentrations, the process of establishing baseline values can be challenging. Here, data for the Burger study area in the northeast Chukchi Sea are presented for metal s and hydrocarbons in sediments to demonstrate that useful baseline values already exist. In addition, the data from the Burger study area are viewed within the context of the overall northeast Chukchi Sea.

1.5.1. Metals

Concentrations of 19 metals in 18 sediment samples collected from the Burger A drill site in the northeastern Chukchi Sea during 2012 ha d an average RSD of ~7% (Table 7; also see sampling locations in Figure 7). These results show that sediment metal concentrations and sediment composition were ve ry uniform at the Burger A drill site. For Ag, Cd and MeHg, RSDs >10% were due in part to the very low natural concentrations of these metals. In contrast, the high RSD for As was due to As enrichment in surface sediments at a few stations due to natural d iagenetic processes (Table 1, Trefry et al. 2010). The data in Table 7 provide a valuable and strong characterization of baseline metal concentrations in the Burger A drill site because of the low variability for most metals.

Table 7: Concentrations of met als (mean ± SD) in sediment samples from 2012 study of Burger A drill site.

Parameter (n = 18)	Ag (µg/g)	Al (%)	As (µg/g)	Ba (µg/g)	Be (µg/g)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Fe (%)	Total Hg (ng/L)
Mean	0.14	6.09	13.0	625	1.4	0.19	85	17.0	3.5	39
SD	0.02	0.17	3.3	14	0.1	0.02	3	1.3	0.2	3
RSD[1]	14	2.8	25	2.2	7.1	10	3.5	7.7	5.7	7.7

Parameter	MeHg (ng/g)	Mn (µg/g)	Ni (µg/g)	Pb (µg/g)	Sb (µg/g)	Se (µg/g)	Sn (µg/g)	Tl (µg/g)	V (µg/g)	Zn (µg/g)
Mean	0.14	6.09	13.0	625	1.4	0.19	85	17.0	3.5	39
SD	0.02	0.17	3.3	14	0.1	0.02	3	1.3	0.2	3
RSD[1]	14	2.8	25	2.2	7.1	10	3.5	7.7	5.7	7.7

[1]RSD = (SD/mean) x 100%.
Mn = manganese
V = vanadium

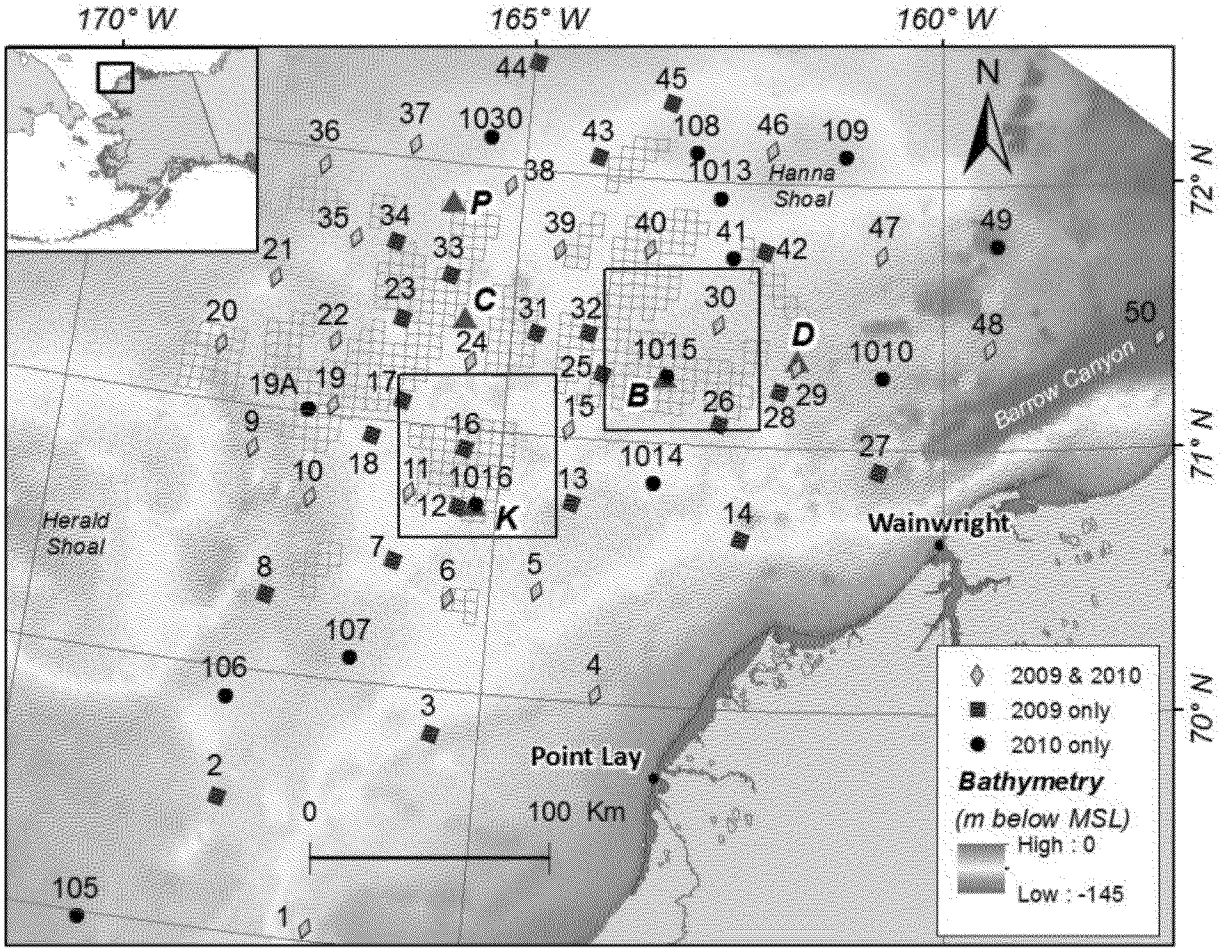


Figure 7: Location of Burger A drill site and other sampling stations in the northeastern Chukchi Sea. The stations identified with markers were sampled as part of the COMIDA project (Dunton et al. 2012). The two squares identify the Burger (B) and Klondike (K) study areas.

More than 300 additional sediment samples from the northeastern Chukchi Sea have been collected and analyzed for the same 19 metals. This data set includes 69 samples from the Burger study area (square marked B in Figure 8) and 259 samples from outside of the Burger study area, in the northeastern Chukchi Sea in general (Figure 8, Table 8). Although metal concentrations in surface sediments from the Burger A drill site were very uniform, a five-fold range in concentrations of Al and other metals has been found throughout the northeastern Chukchi Sea (e.g., Figure 9A). The lowest concentrations of Al were found near the coast in sand and gravel and in the sandy sediments of Hanna Shoal. The highest concentrations of Al were found offshore in silt- and clay-rich sediments (figures 9A and 9B). The distribution of fine-grained sediment (silt + clay) follows that observed for Al (Figure 9A) because fine-grained sediment contains Al-rich clays (i.e., aluminosilicates). Therefore, concentrations of Al were positively correlated with silt + clay content because concentrations of Al are very low in coarse-grained quartz sand and carbonate shell material and are much higher in fine-grained aluminosilicates.

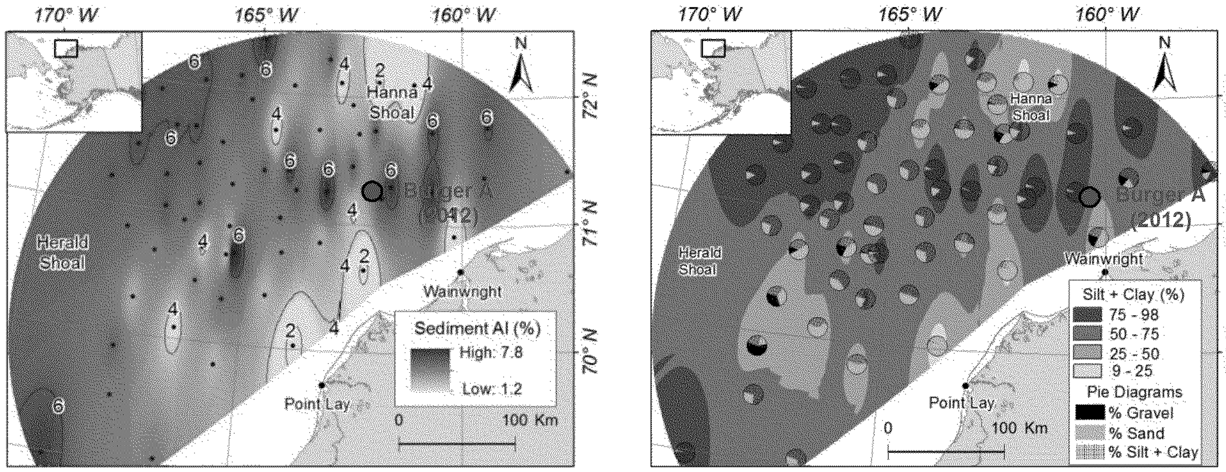


Figure 8: Contour maps for (A) concentrations of aluminum (%) , and (B) % silt + clay with pie diagrams showing gravel (black), sand (blue) and silt + clay (cross -hatched) in surface sediments. Solid circles show the 58 stations that were used to determine baseline metal concentrations in sediments from the northeast Chukchi Sea. Red circle shows location of the Burger A drill site.

Table 8 : Summary of sediment and biota samples collected in the northeastern Chukchi Sea, including the 2012 Burger A drill site.

Area	Year Collected	# Surface Sediment Samples	# Samples from Cores (# cores)	# Pools of Clam Samples (*Astarte* spp.)	# Water Samples (filtered)
NE Chukchi Sea					
Burger A drill site	2012	18	-	17	-
Burger study area	2008-2010	46	23 (3)	17	6
Northeastern Chukchi Sea	2009-2012	76	183 (12)	5	88

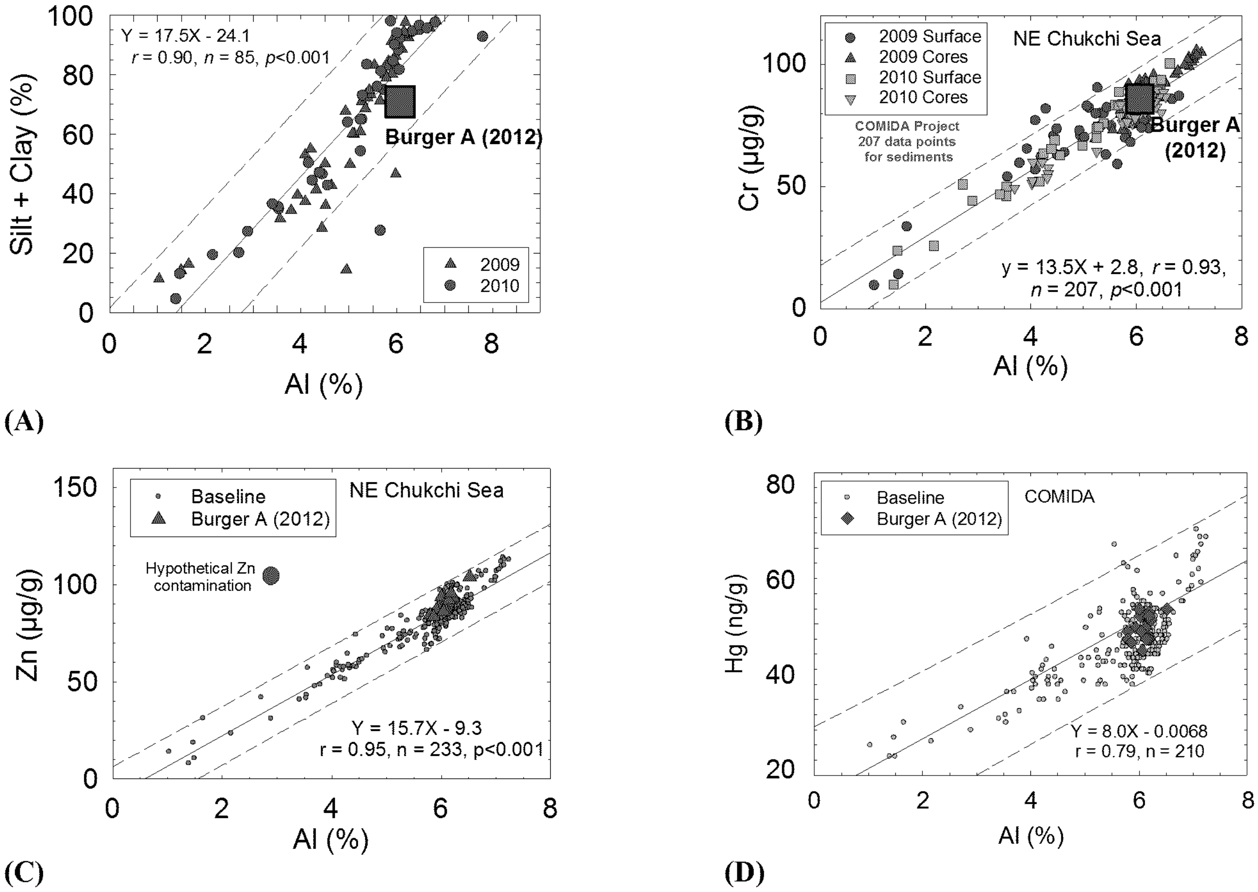


Figure 9: Concentrations of (A) silt + clay vs. Al, (B) Cr vs. Al, (C) Zn vs. Al , and (D) Hg vs. Al, for surface sediments from baseline stations throughout the northeastern Chukchi Sea. Equations and solid lines are from linear regression calculations for the 2009-2010 data from the COMIDA project (Dunton et al. 2012); dashed lines show 99% prediction i ntervals; *r* is the correlation coefficient; *n* is the number of samples; and *p* is the probability factor.

Sediment concentrations of Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Sn, V and Zn also varied considerably throughout the northeastern Chukchi Sea; however, they were strongly correlated (r = 0.7-0.9) or very strongly correlated ($r > 0.9$) with concentrations of Al (e.g., Cr, Zn and Hg in Figures 9B, C and D) and thus followed the same geographic trends described for Al (Figure 9A).

Corresponding trends for the absolute concentrations of Al and trace metals can be explained by variations in grain size, TOC and/or mineralogy because these three variables control metal concentrations in sediments (Trefry et al. 2003). Metal concentrations are normalized to Al, the most abundant metal in marine sediments, to provide a useful mechanism for identifying background metal concentrations as described below (Bruland et al. 1974; Trefry and Presley 1976; Schropp et al. 1990; Trefry et al. 2003). Our assumption is that, with out detectable anthropogenic inputs, natural concentrations of metals will plot within the 99% prediction intervals calculated from linear regression analysis, as shown on plots of individual metals vs. Al concentrations (e.g., Figure 9).

For the northeastern Chukchi Sea, a complete series of 17 graphs of metal concentrations vs. Al concentrations, such as those in Figures 9B, C and D, have been prepared (Trefry et al. 2012) to define baseline concentrations of the 17 metals listed in Table 7. These are essentially the same metals listed by the U.S. EPA for analysis at drilling sites (the one exception is Ti). The prediction intervals on these plots of individual metals vs. Al concentrations define baseline metal concentrations throughout the northeastern Chukchi Sea. Metal concentrations in samples collected from a new location in the northeastern Chukchi Sea, such as any of the other Burger study area sites, should plot within the established prediction intervals on the relevant graph. In other words, a master baseline for the northeastern Chukchi Sea has been established. Significant, positive deviations from a linear trend, such as shown by a hypothetical example for Zn contamination (Figure 9C), can be used to identify past or future metal contamination (or diagenetic remobilization), as described here and with more detail in Trefry et al. (2003).

1.5.2. Hydrocarbons

Polycyclic aromatic hydrocarbon (PAH) data for sediment samples from the CSESP and the Shell DMP were used to evaluate the hydrocarbon chemistry for this exercise. The data analysis was conducted by analyzing the data statistically and presenting the information graphically. PAHs are the class of hydrocarbons that generally are of greatest interest from an environmental, ecological and toxicological perspective. The hydrocarbon data was compiled, analyzed and summarized with selected statistical methods and also plotted to compare concentrations within and among these data sets.

When comparing data between studies, it is important that the data (e.g., target analytes and analytical methods) are comparable and that any differences in methods are understood and can be accounted for. The 2008 Burger study area CSESP and 2012 Burger A drill site sediment samples were collected the same way, were analyzed by the same laboratory with the same methods, and can be compared with confidence. The samples were collected to represent the top 2 cm of the surface sediment, the target analytes were the same, and the analytical methods used were the same. A total of 42 PAH parameters, including several alkylated PAH homologous series, were measured in the PAH analysis. The PAH analytical results for the two Chukchi Sea datasets are summarized in Table 9. The mean concentrations for the Total PAH compounds are presented along with the SD and the minimal (Min) and maximal (Max) sample concentrations. These data also are presented graphically in Figures 10 and 11.

Table 9: Summary of concentrations of hydrocarbons (µg/kg dry weight [DW]) in the upper 2 cm of sediments at the Burger study area (2008) and the Burger A drill site (2012) in the Chukchi Sea.

	Burger study area (29 samples)				Burger A drill site (20 samples)			
Hydrocarbon parameter	Mean	SD	Min	Max	Mean	SD	Min	Max
Total PAH (Σ42)	300	93.1	121	482	304	25.0	264	365

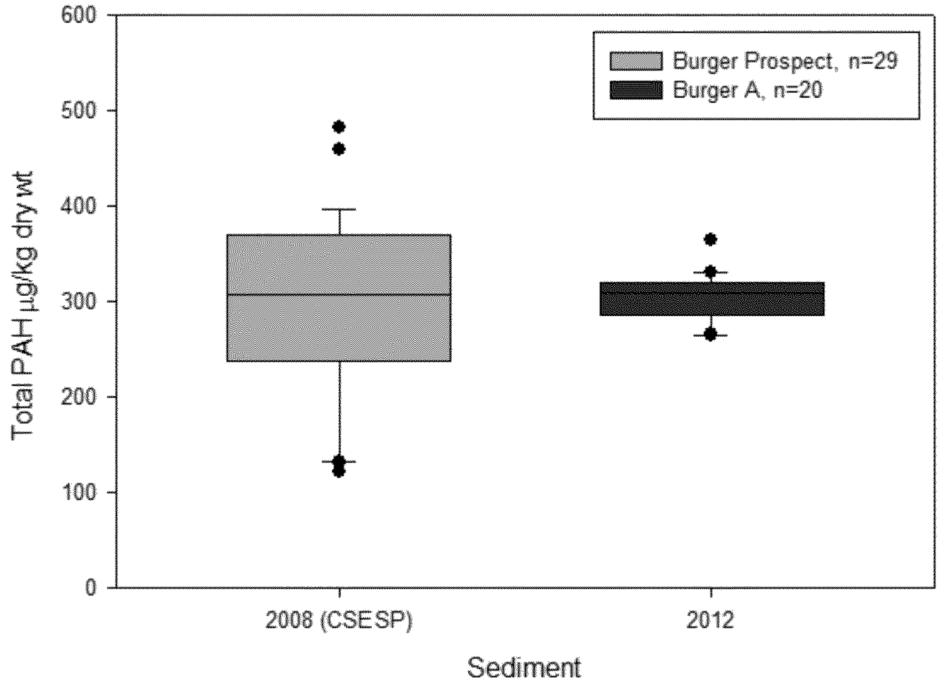


Figure 10 : Summary of Total PAH concentrations (µg/kg DW) in sediment samples from the Burger study area (2008) and the Burger A drill site (2012) of the Chukchi Sea. Horizontal line in the box represents the median value.

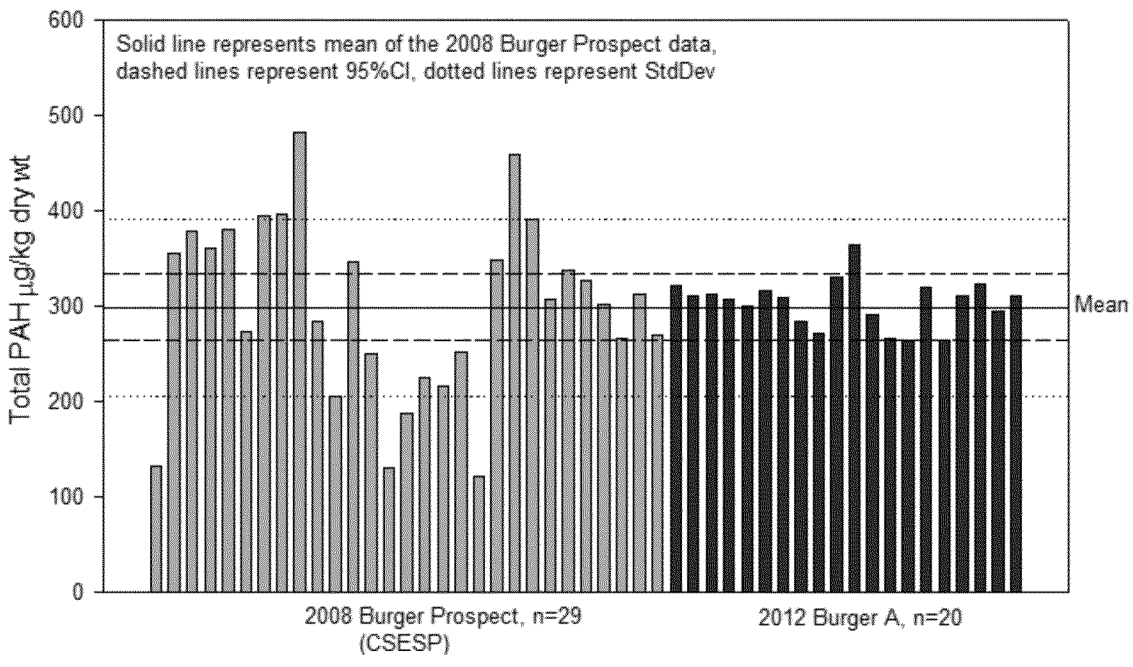


Figure 11: Total PAH concentrations (µg/kg DW) in sediment samples from the Burger study area (2008) and the Burger A drill site (2012) of the Chukchi Sea with the mean concentration, the 95% confidence intervals (dashed lines), and the SD (dotted lines) shown for the Burger study area samples.

Average sediment Total PAH concentration for 2008 Burger study area samples and Burger A drill site samples was 300 and 304 µg/kg DW, respectively. Variability within those two datasets was slightly greater for the Burger study area samples (Figure 10) than the Burger A drill site samples, with a SD of 93 µg/kg DW (Table 9) that translates to a %RSD of 30. In contrast, variability was very small for the Burger A drill site samples, which had a SD of 25 µg/kg DW (%RSD of 8%).

The data analysis also included normalizing the PAH concentrations to common data-normalizing parameters, to account for natural variability due to differences in sediment characteristics that may otherwise confound the data analysis. These sediment characteristics included using sediment TOC concentration, grain size (represented by the %fines [silt + clay]), and perylene (a non-petroleum, primarily biogenic, PAH that is abundant in some sediments). PAH concentrations in the Burger study area and the Burger A drill site generally covaried with all three parameters, increasing with increasing %TOC, %fines, and perylene (Figure 12). These relationships were not strong and did not indicate that these were major drivers of the hydrocarbon concentration. The %TOC and %fines may help to predict site-specific hydrocarbon concentrations. For example, the Burger study area TOC-normalized Total PAH concentrations were predictive of the Burger A drill site concentrations (Figure 12).

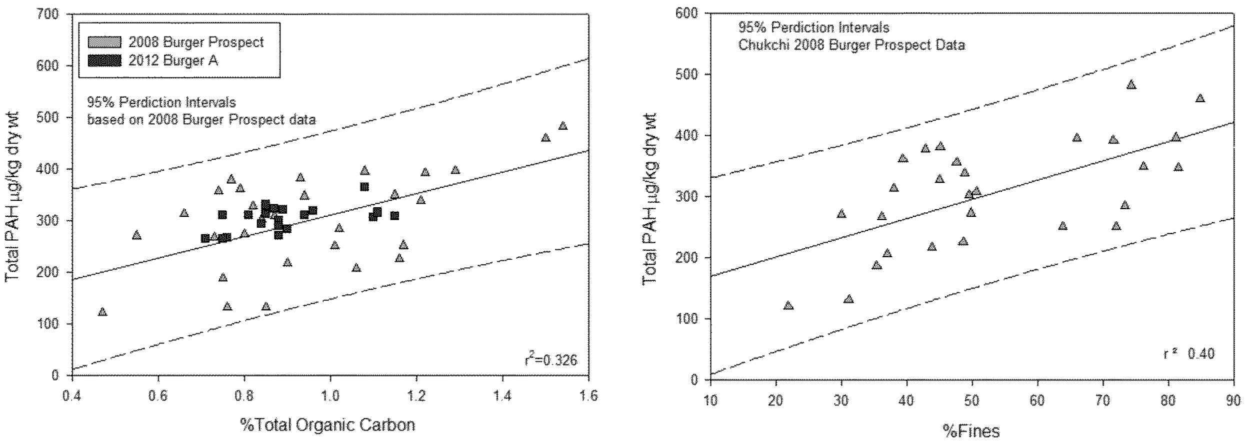


Figure 12: Total PAH concentration (µg/kg DW) vs. %TOC for the Burger study area (2008) and the Burger A drill site (2012) samples (top), and the Total PAH concentration (µg/kg DW) vs. % fines for the Burger study area (2008) samples (bottom).

One-way analyses of variance (ANOVA) and Mann-Whitney tests were conducted on both data sets, comparing them with each other to test for differences (or, conversely, similarity; Table 10). Total PAH concentrations in sediments were not significantly different between the Burger study area and the Burger A drill site ($p = 0.879$).

Table 10: Mann-Whitney tests for difference in median concentration of PAH (µg/kg DW) in the upper 2-cm of sediments between the Burger study area (2008) and the Burger A drill site (2012).

	Burger study area (29 samples)	Burger A drill site (20 samples)		
Parameters	Median	Median	*U*-statistic	*p*-value
Total PAH	308	310	492	0.879

The data from the Burger study area are very similar to those from the Burger A drill site and appear to be highly predictive of site-specific concentrations in the Burger A drill site (Figure 12). Mean Total PAH concentration is statistically equivalent for these two datasets (300 and 304 μg/kg DW), and the mean and confidence intervals for the Burger study area data generally predict the concentration range that would be expected at a specific location within the broader study area, such as at Burger A drill site (dashed lines in Figure 11), with few exceptions. As expected, the SD for the Burger study area data (dotted lines in Figure 11) covers a slightly wider range than does the confidence intervals and fully captures variation in the site -specific data. These predictions are based solely on sediment PAH concentrations and incorporate differences from varying sediment characteri stics (e.g., TOC content, grain size). The prediction can be refined further by factoring in the small influence TOC content and grain size have on PAH concentrations in the Burger study area and Burger A drill site (Figure 12).

1.6. Benthic Community Bioaccumulation Monitoring

Bioaccumulation is the uptake of chemicals over time in an organism. Coastal monitoring programs have existed in the U.S. for many decades (e.g., the "Mussel Watch Program ," U.S. National Status and Trends Program) and primarily have used bivalves to measure the bioaccumulation of various persistent organic p ollutants such as PAHs, polychlorinated biphenyls (PCBs), and pesticides such as dichlorodiphenyltrichloroethane (DDT) (Gunther et al 1999). By measuring the chemical body burden in th e tissues of organisms that do not readily metabolize the compounds of interest, an understanding of the amount of compound that is bioavailable (i.e., actually taken up by the organism) in the water or sediment can be gained. By examining organisms at the lower level of the food chain (e.g., bivalves), a greater understanding can be gained of the magnitude of chemical concentration through the food web. The simplest way to measure bioaccumulation is to determine the concentrations of chemicals of interest in the organisms of interest and compare these concentrations to sediment concentrations.

Typically, biota -sediment accumulation factors (BSAFs) are a good gauge of bioaccumulation for hydrophobic organic contaminants in sediment -dwelling (i.e., benthic) species such as clams. In this study, bioaccumulation will be assessed by measuring contaminant concentrations in two different environmental compartments (sediment, biota) and calculating BSAF values. Once calculated, these values can be compared between b aseline or Phase I data and Phase III and IV data to determine whether bioaccumulation of particular chemicals has increased as a result of drilling operations. B ioavailability of these compounds is also indirectly measured using BSAF calculations because only the freely dissolved fraction will be available for uptake into the organism (particularly in filt er-feeding species such as clams. Depuration on -vessel will aid in limiting sediment gut contributions to total chemical concentrations). BSAF values are calculated by dividing the lipid -normalized tissue concentration of a particular analyte by the organi c carbon-normalized sediment concentration of the same analyte. BSAF values less than 1 typically indicate a particular compound is not fully bioavailabl e to the organism evaluated. This concept is appropriate for hydrophobic organic chemicals (e.g., PAHs).

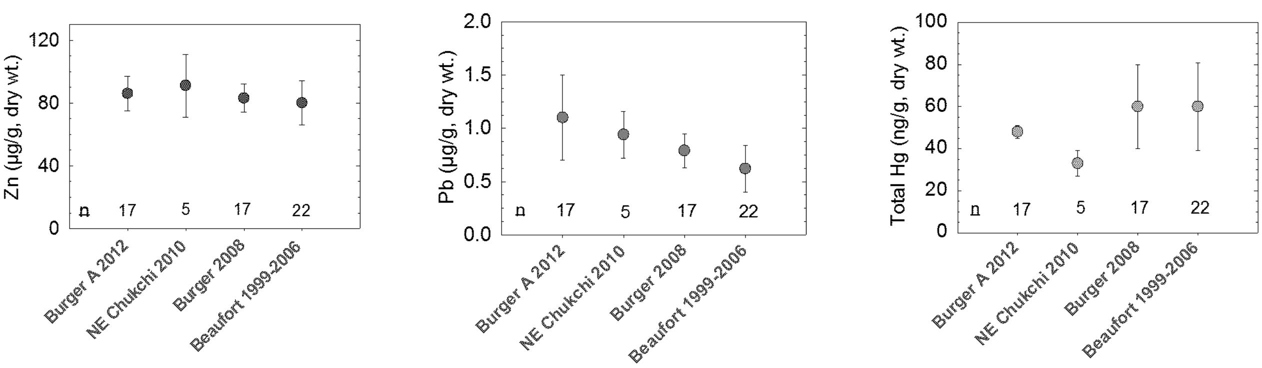
Benthic community bioaccumulation monitoring is a required component of Phase I baseline characterization for operators that plan to discharge water-based drilling fluids and drill cuttings

(Discharge 001). The Phase I component could be replaced by data that already exist for biota (primarily clams). Clams were used because they are an important indicator animal for monitoring hydrocarbons in the environment. Clams are sessile and useful for conservatively assessing bioaccumulation potential. They effectively bioaccumulate bioavailable contaminants such as PAH and do not readily metabolize or excrete such compounds like many other animals do.

Significant issues exist for collection of clams in the Chukchi Sea due to natural patchiness in abundance, challenges with obtaining sufficient tissue mass for laboratory chemical analysis, difficulty with collecting tissue samples of identical species, and gut contributions to body-burden measurements. Furthermore, chemical concentrations in biota are typically more variable than those in sediments. As such, these data are not as effective at demonstrating moderate changes in chemical concentrations due to anthropogenic impacts. Every effort will be made to collect clams in the field; however, the challenges must be acknowledged.

1.6.1. Metals (Clams)

Bioaccumulation of metals historically has been monitored by using immobile, sentinel bivalves. For example, mussels and oysters have been used for such purposes in the U.S. National Status and Trends Program from 1986 to present (Kimbrough et al. 2008). Clams (*Astarte* spp.) have been used for monitoring bioaccumulation in the Chukchi and Beaufort seas (e.g., Neff et al. 2009, 2010; Dunton et al. 2012). Metal concentrations in clams collected during 2012 from the Burger A drill site were highly variable, with an average RSD of 39% (Table 11). Zinc, which is an essential element for clams, is regulated biochemically by Zn-bearing enzymes; consequently, variations in clam Zn concentrations (RSD = 12%) were smaller than observed for some non-essential metals such as Cd, Pb and Sn (Table 11 and Figure 13 for Zn, Pb and Hg).



(A) (B) (C)

Figure 13: Means (marker) ± SDs (lines) for concentrations of (A) Zn, (B) Pb, and (C) total Hg for clams (*Astarte* spp.) from Burger A drill site and other areas in the north east Chukchi Sea and the Beaufort Sea (*n* = number of samples).

Table 11: Concentrations of metals (mean ± SD) for clam (*Astarte* spp.) samples from 2012 for Burger A drill site and other northeast Chukchi Sea locations.

Parameter	Ag (µg/g)	As (µg/g)	Ba (µg/g)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Fe (%)	Total Hg (ng/g)
Burger A drill site (2012) (*n* = 18)								
Mean	0.26	13.1	21.6	13.5	1.3	15.3	2200	48
SD	0.11	4.3	4.5	13.1	0.4	2.2	746	3
RSD[1]	42	33	21	98	31	14	34	6
Burger study area and NE Chukchi Sea (2008, 2010, *n* = 20)								
Mean	0.22	11.8	14.2	34	1.3	9.6	1400	49
SD	0.16	1.4	9.6	12	0.3	2.5	770	19
RSD[1]	72	12	68	36	22	26	55	40

Parameter	MeHg (ng/g)	Ni (µg/g)	Pb (µg/g)	Se (µg/g)	Sn (µg/g)	V (µg/g)	Zn (µg/g)
Burger A drill site (2012, *n* = 18)							
Mean	7	5.6	1.1	4.2	0.14	5.7	86
SD	2	3.3	0.4	1.3	0.11	2.6	10
RSD[1]	33	58	39	30	83	46	12
Burger study area and NE Chukchi Sea (2008, 2010, *n* = 20)							
Mean	10	-	0.7	8.4	-	3.4	83
SD	2	-	0.1	1.5	-	2.2	11
RSD[1]	19	-	12	18	-	65	14

[1]RSD = (SD/mean) x 100%.

Metal data for clams from Burger A drill site (Table 11) provide a suitable baseline for identifying future assessment of metal contamination in biota. Overall metal concentrations in clams from the Burger A drill site are consistent with results for other locations in the Burger study area and throughout the northeast Chukchi Sea. Therefore, the existing data from Burger A drill site and throughout the northeast Chukchi Sea provide a suitable and valuable baseline for metals in clams from other locations in the northeast Chukchi Sea, including other Burger drill sites. As has been noted for the U.S. National Status and Trends Program, observed natural variations in metal concentrations in bivalves limit the sensitivity of identifying increased values due to contamination; however, marked metal contamination would still be discernible in these *Astarte* clams from the northeast Chukchi Sea.

1.6.2. Hydrocarbons (Clams)

Two data sets on PAH chemistry in biological tissues from the Chukchi Sea were used to determine if sufficient baseline information exists for site-specific locations in the Burger study area. The samples were collected from the same two general areas as the samples used for the sediment PAH analysis: samples from the Burger study area collected in 2008 as part of the

CSESP monitoring represented the largest geographical area; and samples collected in 2012 as part of Shell's DMP represented the area around the Burger A drill site. The data analysis focused on polycyclic aromatic hydrocarbon (PAH) concentra tions in clams. PAHs were used to represent the hydrocarbons because they are the class of analytes that are of greatest interest from a bioaccumulation and environmentally relevant perspective.

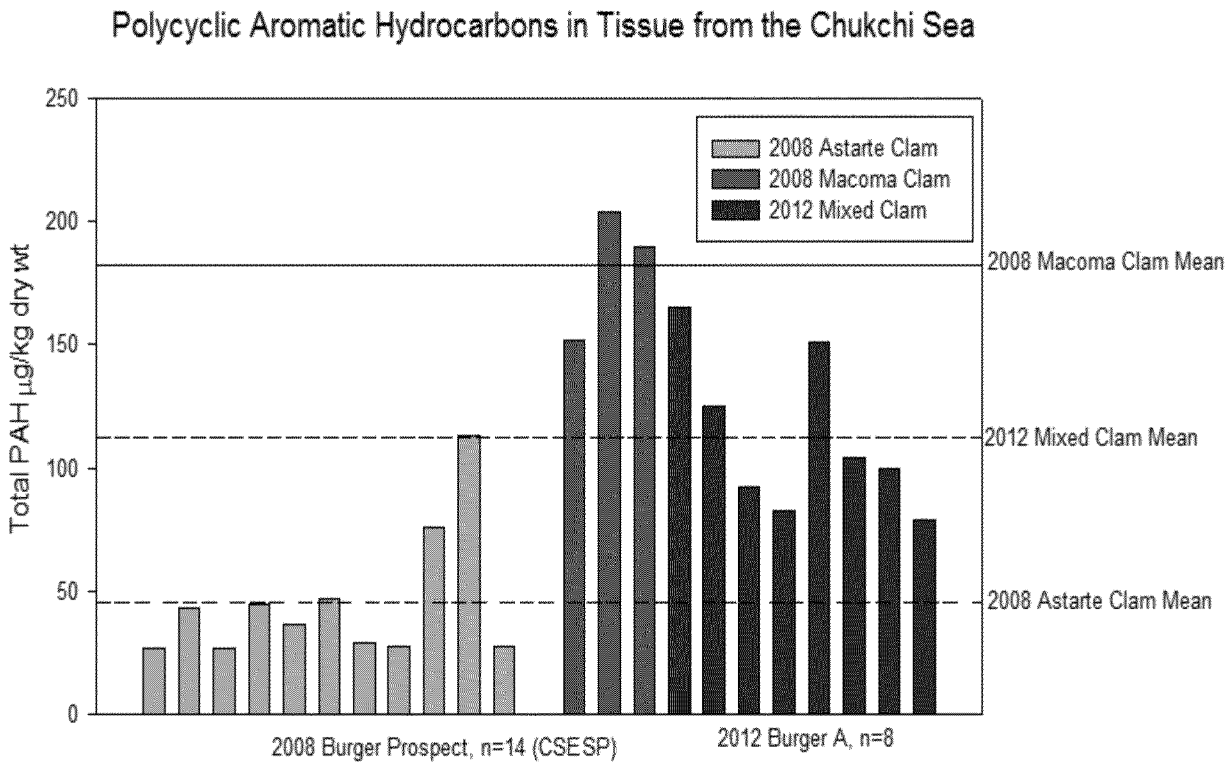
The Burger study area data set consisted of 11 *Astarte* spp. clam samples and three *Macoma* spp. clam samples collected in 2008. The Burger A drill site samples collected in 2012 consisted of 8 samples of a mixture of clam species. The PAH analytical results for the two Chukchi Sea datasets are summarized statistically in Table 12: Table 12a shows the data on a DW basis; Table 12b shows the data on a lipid-normalized basis. M ean Total PAH concentrations are pre sented along with the SD, 95% confidence interval (CI), and the Min and Max sample concentrations. These data also are presented graphically in Figure 14.

Table 12a: Total PAH concentration (µg/g DW) in clams collected in the Burger study area in 2008 and at the Burger A drill site in 2012.

Study Area	Sample Type	*n*	Mean	SD	C.I. of Mean	Min	Max
2008 Burger study area	*Astarte* clam	11	45.	26.	18.	26.	11
	Macoma clam	3	18	26.	66.	15	20
2012 Burger A drill site	Mixed clam	8	11	31.	26.	79.	16

Table 12b: Total PAH concentration (µg/g lipid) in clams collected in the Burger study area in 2008 and at the Burger A drill site in 2012.

Study area	Sample Type	*n*	Mean	SD	C.I. of Mean	Min	Max
2008 Burger study area	*Astarte* clam	11	3.8	2.9	2.0	1.6	12.0
	Macoma clam	3	4.8	1.2	3.1	3.4	5.8
2012 Burger A drill site	Mixed clam	8	4.3	0.6	0.5	3.6	5.0



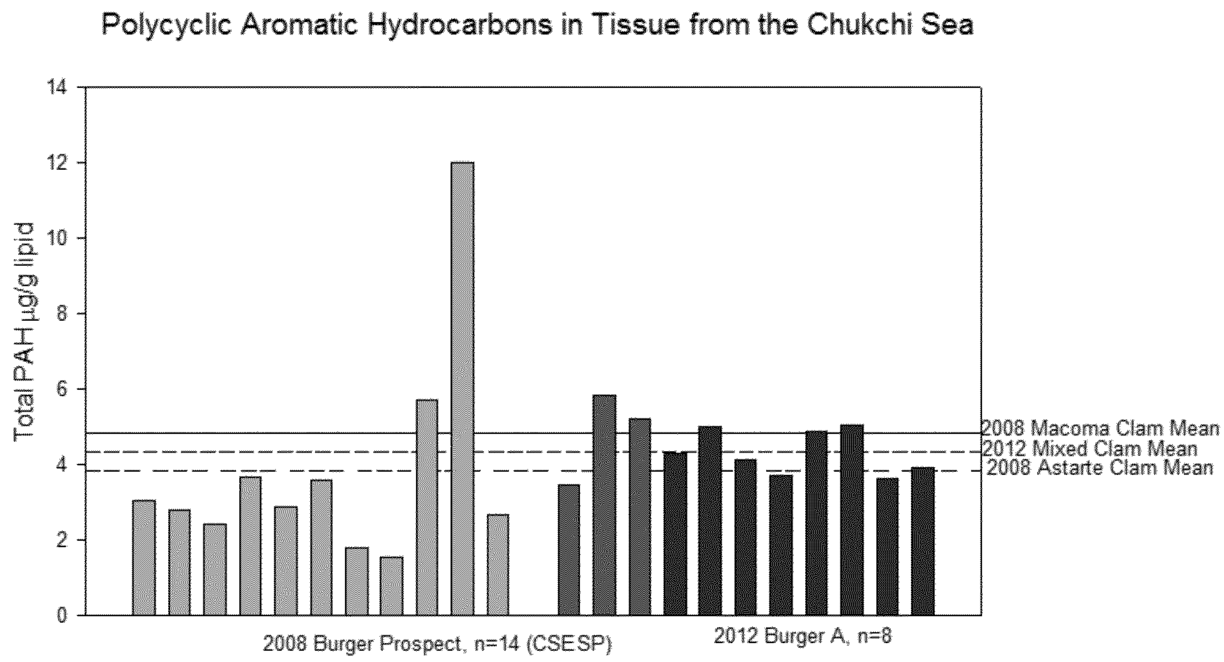


Figure 14: Total PAH concentrations in Chukchi clam samples from the Burger study area and Burger A drill site. Concentrations are in µg/kg DW (top) and µg/g lipid (bottom).

Average clam-tissue Total PAH concentrations for the 2008 Burger study area CSESP samples were 45.3 and 182 µg/kg DW for the *Astarte* and *Macoma* clams, respectively. The average Total PAH concentration was 113 µg/kg DW for the mixed-clam samples collected from Burger

A drill site in 2012. There was clearly a large difference in mean PAH concentration between the two species; but, the variability within a species and the difference between the species was quite small once the data were lipid -normalized (Table 13 and bottom chart Figure 14). The lipid content of the *Macoma* clam samples (which had the highest PAH concentrations on a DW basis) averaged 3.85%, and the average lipid content for the *Astarte* clams was 1.20%. It is clear that lipid content drives the accumulation of PAH in these clam samples. The Total PAH concentration strongly co-varied with the amount of lipid in the sample (Figure 15), as can be expected for bioaccumulation of most hydrophobic organic compounds.

Table 13: Total PAH concentration (µg/g lipid) in clams collected in the Burger study area in 2008 and at the Burger A drill site in 2012.

Study	Sample Type	*n*	Mean	SD	C.I. of Mean	Min	Max
2008 Burger study area	Mixed clam	14	4.0	2.7	1.5	1.6	12.0
2012 Burger A drill site	Mixed clam	8	4.3	0.6	0.5	3.6	5.0

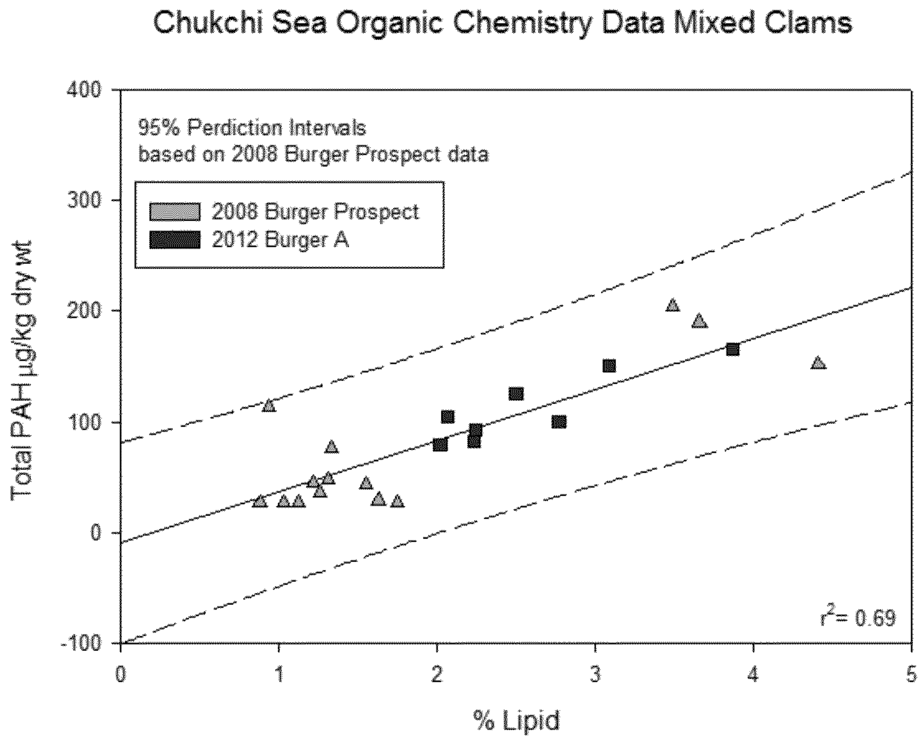


Figure 15: Total PAH concentration (µg/kg DW) vs. % Lipid for the Burger study area (2008) and the Burger A drill site (2012) and clam tissue samples.

Normalizing the data to the lipid content for the most part removed the influence that the specific clam species had on the data, and the *Astarte* and *Macoma* clam data could be combined for subsequent data analysis (Table 14 and Figure 1 6). Combining the data also made it possible to compare the 2008 and 2012 data with confidence because the 2012 samples were a mixture of species (e.g., *Astarte*, *Macoma*, and possibly other).

ANOVA and Mann-Whitney tests were also performed on both data sets, comparing them with each other to assess whether they differed (Table 14). The Total PAH (lipid-normalized) concentrations were not significantly different for samples collected in the Burger study area and in the Burger A drill site (p= 0.125).

Table 14: Mann-Whitney tests of data for clam tissue collected in the Burger study area in 2008 and at the Burger A drill site in 2012. Data for the 2008 *Astarte* and *Macoma* clams are combined (the 2012 clam samples consisted of mixed clam species).

	Burger study area 2008, n=14	Burger A drill site 2012, n=8		
Parameter and Concentration Basis	Median	Median	U-statistic	p-value
Total PAH (µg/kg DW)	44.0	102		
Total PAH (µg/kg lipid)	3.20	4.20	115	0.125

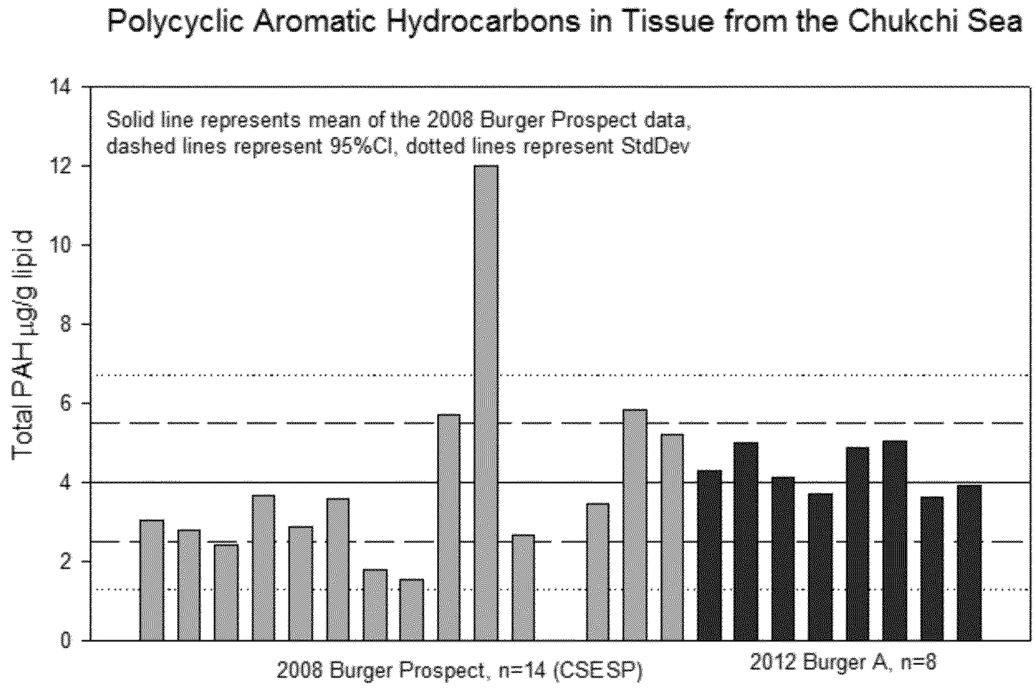


Figure 16: The Total PAH concentrations in Chukchi clam samples from the Burger study area and Burger A drill site. Concentrations are in µg/g lipid with the mean concentration, the 95% confidence intervals (dashed lines), and the SD (dotted lines) for the Burger study area data.

The lipid-normalized data from across the Burger study area (the 2008 CSESP data) are very similar to the 2012 Burger A drill site data and appear to be highly predictive of site-specific Total PAH concentrations in clams collected anywhere within the Burger study area (Figure 16). The mean Total PAH concentration is statistically equivalent for these two study areas. The mean and confidence intervals for the Burger study area data predict the concentration range that would be expected at a specific site, such as Burger A drill site (dashed lines in Figure 16). The

95% prediction intervals for Total PAH concentration vs. %Lipid relationship is also highly predictive of the PAH concentration.

The data in Figure 15 suggest that most of the samples from 2012 are a mixture of *Astarte* and *Macoma* clams and possibly other species. The light blue triangles for the 2008 samples (%Lipid ~1-2%) are the *Astarte* clams, while the light blue triangles (%Lipid ~4%) are the *Macoma* clams. The dark blue squares represent the mixed clam samples collected in 2012, and those fall in between, suggesting that they may be a combination of mostly *Astarte* and *Macoma* because those are the most abundant clams in this area. The e xception is the dark blue square towards the right (near 4% Lipid), which clusters with the 2008 *Macoma* samples, suggesting that 2012 sample may have been primarily composed of *Macoma* clams.

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ATTACHMENT A

Burger A Pre-Drill Sediment Profile Imaging Survey